| Los Alamos National Laboratory<br>**Environmental Restoration Program**<br>Standard Operating Procedure | No: LANL-ER-SOP-10.04 Rev: 1 |
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# FIDLER INSTRUMENT SYSTEM

| | Print Name | Signature | Date |
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# FIDLER INSTRUMENT SYSTEM

## Contents

# FIDLER INSTRUMENT SYSTEM

## 1.0 PURPOSE

The following procedures outline the methods involved in the use of two instruments. One is the Environmental Protection Groups (ESH-8's) Multichannel Analyzer (MCA)-465/Field Instrument for Detecting Low Energy Radiations (FIDLER) instrument system (TSA Systems, 1992 a, b). The second is the use of the Ludlum Model 2221 single channel analyzer (Ludlum Measurements, 1989). Both instruments use the BICRON FIDLER thin NaI crystal detector.

Specific procedures are given for: 1) Calibration of an Energy Spectrum and setting Regions of Interest; 2) Quality Control Checks; and 3) Field Use.

## 2.0 SCOPE

Adequate controls shall be established to ensure that only correct and acceptable field measurements will be collected with the FIDLER in support of Environmental Management operations performed for the Department of Energy.

### 2.1 Applicability

These instruments are used in soil radiological surveys conducted at Los Alamos National Laboratory (the Laboratory). The Waste Site Studies (WSS) team of ESH-8 provides support to the Environmental Surveillance Program, to the Environmental Restoration (ER) Program investigations of potential release sites, and to the decommissioning and decontamination actions at the Laboratory.

Because the Laboratory routinely characterizes, handles, and disposes of soils contaminated with alpha- and beta-emitting radionuclides (accompanied by gamma and x-ray emissions) there is a need for a detector that can field-monitor soils and areas potentially contaminated with x-ray or low-energy gamma emitters.

The FIDLER detector is a scintillation detector that, when associated with a MCA or Single Channel Analyzer, has the ability to measure low-energy gamma and x-ray energies that may accompany alpha and/or beta decay.

### 2.2 Features

#### 2.2.1 Features of the TSA MCA-465:

- 256 channel MCA
- 4 energy spectrum Regions of Interest (ROI) are available
- 14 memory locations for storing collected spectra are available
- RS-232 connector and associated software package to allow for memory transfer to Personal Computer (PC) and PC Set-Up

- Internal 1" x 2" NaI detector for measuring external penetrating background radiation

#### 2.2.2 Features of the Ludlum 2221

- Gross count mode or single channel analysis
- Ratemeter and scaler count modes
- Four linear analog count rate scales and a log count rate scale
- Choice of time constants
- Selectable audio rate divider

### 2.3 Training

Personnel using these instruments will have been informed of the hazards associated with measuring radioactivity on soils. Both HAZWOPER and Radiation Worker Training will be required of personnel using these instruments. Training in the use of equipment owned by WSS will be the responsibility of WSS management. Calibration of equipment owned by WSS will be conducted only by WSS management or other WSS trained personnel. WSS may review and approve training of non-WSS personnel and calibration procedures used for non-WSS instruments. Training for Quality Control, determination of detection limits, and field use will be required for all users of the FIDLER. Training documentation includes: 1) list of individuals authorized to use the system; 2) date of completed training; 3) signature sheet indicating review of this standard operating procedure; and 4) signature sheet indicating completion of in-the-field training and use of the instruments.

## 3.0 INSTRUMENTATION AND DEFINITIONS

### 3.1 Definitions

<u>BICRON FIDLER</u> - a thin NaI crystal detector assembly that is sensitive to the low energy gamma and x-rays emitted by various radionuclides.

<u>MCA</u> - a system that collects amplified output signals from a detector and sorts them into the appropriate channels based on the energy of the incident radiation.

<u>NaI (Sodium Iodide)</u> - a hygroscopic, inorganic crystal which emits UV photons (scintillates) as a result of a gamma or x-ray depositing energy in the crystal.

<u>ROI</u> - this is the region around a Total Absorption Peak (TAP) of interest.

<u>Single Channel Analyzer</u> - a system that collects output signals from a detector and accepts only signals corresponding to a certain energy range.

### 3.2 Instrumentation

### 3.2.1 MCA-465/FIDLER

For operating the MCA electronics package as outlined in Section 6.0, the nomenclature used is described below:

- Words in capital italics refer to the menus available on the MCA readout.
- Underlined words refer to options available under the given menu.
- Words in double quotes refer to information that is displayed in a particular option.
- Words enclosed in arrows, e.g., <ENTER> refer to keys on the MCA.

In Addition:

- Options are selected using the up and down arrows.
- Option menus are selected by using the right arrow.
- Parameters are stored using the <ENTER> key.

### 3.2.2 LUDLUM 2221

High voltage is adjusted with rotation of the high voltage control with indication of the voltage on the LCD display. The numerical value displayed is not necessarily the actual voltage across the detector, however, the relative value is adequate for set-up and calibration. The "voltage" is properly set by adjustment while the detector is exposed to a source of known energy, i.e., the 59.5 keV gamma ray from Americium-241 (241-Am), as described in Section 6.1.2.

## 4.0 BACKGROUND AND PRECAUTIONS

1. The Photomultiplier Tube (PMT) operates at high voltage. Thus, care should be taken when connecting the signal cable to the output and input on the detector.

2. Changes in temperature cause gain shifts with the PMT, thus PMTs are temperature sensitive and rapid temperature changes can damage the NaI crystal. Always allow the FIDLER to warm up or cool down at a rate not exceeding 10°C (18°F) per hour. Sufficient warm-up time is needed before use. Ten minutes should be an adequate warm up time for this instrument.

3. Care must be taken to preclude any damage to the exposed beryllium window of the detector.

## 5.0 EQUIPMENT

### 5.1 MCA-465/FIDLER

1. BICRON FIDLER Detector
2. TSA Multichannel Analyzer
3. Power Cord

4. Connector Cables
5. Tripod
6. Instrument Stand
7. Check Sources and/or Standards
8. Data Recording Sheet, Tape Recorder, or Personal Computer for the recording of data

### 5.2 2221 FIDLER:

1. BICRON FIDLER Detector
2. LMI 2221 ratemeter-scaler
3. High Voltage Cable
4. Check Sources and/or Standards
5. Data Recording Sheet

## 6.0 PROCEDURES

### 6.1 Calibration (Setting the Regions of Interest)

#### 6.1.1 TSA MCA-465 Calibration Balance

1. Be certain the MCA is turned off before connecting the communications/high voltage cable between the MCA and the detector.

2. Connect the 9-pin cable to the 9-pin external detector plug on the detector unit.

3. Connect the other end of the cable to the 9-pin plug on the MCA.

4. Turn on the MCA. It will go through a self-check before any counting is to be done.

5. Place the source in the source holder. The source element and reference number, activity, and traceability must be recorded and filled with quality assurance records for the FIDLER. These records will accompany data turned into the Records Processing Facility.

6. Place the tripod stand on the source holder.

7. Place the detector unit so that it fits all the way inside the tripod stand. The height of the stand should be adjusted so that the window of the detector is 30 cm (1 foot) from the surface of the source. The serial number for the detector must be recorded.

8. To calibrate the MCA so that the 100 keV energy corresponds to channel number 255, first determine the number of keV per channel using the following:

$$\frac{100\ /keV}{\#\ of\ channels} = \frac{100\ keV}{255} = \frac{0.392\ keV}{channel}$$

With this information, the correct channel number for the energy of a check source can now be calculated. All reference information for the check source must be recorded. For example, using 241-Am as a check source, and measuring the 59.4 keV x-ray emitted, the channel number for this energy is calculated as follows:

$$59.4\ keV \quad * \quad channel\ \# \quad = \quad channel\ \#\ 152$$

9. For this particular TAP, move the cursor on the MCA readout so that it is positioned at channel number 152.

10. Hit <mode> to get into the MODE menu. Choose the SET-UP mode using the cursor and arrow keys.

11. Select the PARAMETERS option by moving the cursor to this option, and pressing the right arrow key.

12. In the PARAMETERS menu, use the arrow keys to select a Live measurement time of "200" (count time of 200 seconds).

13. In the PARAMETERS menu, toggle the Time Mode option so that "Live" is displayed.

14. After the necessary parameters have been set, hit the <ENTER> key to store them in the unit. Exit the PARAMETERS menu.

15. From the SET-UP menu select the CALIBRATE option. The MCA will automatically begin to count the source.

16. Use the arrow keys to move the 59.4 keV peak until it is centered over or under the cursor.

17. Once the peak is centered, hit the <ENTER> key to store the calibration factor in the unit.

18. While still in the SET-UP menu, move the cursor to select the ROI set-up option.

19. The Lo energy and Hi energy ends of the ROIs are set to the Full Width Half Maximum (FWHM) on either side of the peak of interest by using the arrow keys, and hitting <ENTER>. The mode key allows you to set other ROIs once one has been established.

20. Select "Lo I" to be the channel number on the left (lower energy) end of the first peak which contains one-half the maximum number of counts in

that channel for that total absorption peak of interest. Likewise, select "Hi I" to be the channel number on the right (upper energy) end at the FWHM for that total absorption peak. Record the number of the "lo" and "hi" channels.

Note: If no one channel is exactly at the FWHM, use the channel with the closest number of counts to, but lower than, the FWHM as a bracketing channel.

21. For the second total absorption peak and ROI select "Lo II" and "Hi II" using the same criterion that was used to select "Lo I" and "Hi I." Record the numbers of the "Lo" and "Hi" channels.

22. Be sure to hit <ENTER> before exiting the ROI set-up menu.

23. The MCA and FIDLER probe are now energy calibrated.

### 6.1.2 Ludlum 2221 Calibration Balance

1. Be certain the LMI 221 is turned off before connecting the communications/high voltage cable between the MCA and the detector.

2. Connect the high voltage cable to the FIDLER.

3. Connect the other end of the cable to LMI 2221.

4. Turn on the LMI 2221. Check the battery charge level; replace batteries if necessary.

5. Place the FIDLER on the source holder. The source element and reference must be recorded and filed with quality assurance records for the FIDLER. These records will accompany the radiological survey data.

6. Set the threshold to 110 and the window to 20.

7. Starting with a voltage of about 100 volts, adjust the high voltage to maximize the count rate for the 241-Am check source.

8. Set the Window and Threshold as follows:

    a. Leave the high voltage as set by step 7.

    b. Adjust the window to 40.

    c. Adjust the threshold to 100.

**Caution:** This sets the window to the energy range of 50 to 70 keV, which has been determined to be optimal for Am-241. It is not necessarily appropriate for other low energy gamma emitters.

9. The response of the LMI 2221 with FIDLER is now optimized for detecting Americium-241. Record the voltage, window and threshold values for future reference.

10. This procedure will be repeated whenever the quality control chart data indicates the instrument is out of control, and when the FIDLER, LMI 2221, or high voltage cable is replaced.

## 6.2 Daily Source Checks

A quality control source check is to be done each day the instrument is used in the field. The data are recorded on the Gamma Scintillation Detector Operational Check Data Sheet or the ESH-8 FIDLER Survey Sheet. See Attachments A and B. All reference information on the check source is to be recorded along with the count data on the form.

An Instrument Control Chart (Attachment C or similar) is also to be prepared using the data being accumulated on the daily Operational Check Data Sheet. The chart tracks detector response to a known source as a function of calendar days. The chart is used to establish the consistency of detector response from day-to-day and determine acceptability of the data collected. If the chart in Attachment C is used, the following procedure is used (if a different chart is used, its procedure is followed).

After ten days' data are accumulated on the Operational Check Data Sheet, the MCA-465 ROI Totals or the LMI 2221 Total Counts are written into the left-hand column in numerical order and spaced equally from top to bottom, on the Instrument Control Chart (see Attachment B). The date of each determination is written across the top of the grid portion of the chart. A dot or "X" is then placed in the square at the point where the date and its count intersect. The mean of the ten counts is calculated and a line drawn across the chart at this value. As data is accumulated the mean may change in value and the line then relocated as necessary.

A plot of date vs count is thus generated. Lines representing one, two, and three standard deviations from the mean are also drawn in to help establish proper operating limits for the instruments. This process continues for each subsequent daily check as long as the instrument is in use.

### 6.2.1 Materials for Source Checks and Chart Preparation

1. TSA MCA-465 or LMI 2221 FIDLER System
2. Am-241 Source
3. Operational Check Data Sheet
4. Instrument Control Chart

### 6.2.2 Procedure for TSA MCA-465

Place the detector in the tripod stand and place the tripod over the source holder. Place the source in Position 1 of the holder and begin a 200 second count. At the end of the counting period, record the total number of counts in the regions of interest on the Operational Check Data Sheet. After enough data has been accumulated, prepare an Instrument Control Chart and transfer the data to the chart. Draw in the mean, and the first, second, and third standard deviation lines. Continue the process as each daily count is made. If a daily total count falls outside the third standard deviation line, contact the Waste Site Studies instrument owner.

### 6.2.3 Procedure for Ludlum 2221 SCA

1. Verify that the batteries are charged sufficiently and that the high voltage, window and threshold are set exactly as determined by step 6.1.2 of this procedure.

**Caution:** A shift in any of these settings will affect the response check result significantly.

2. Place the Am-241 check source in the source holder. Place the source detector on the source holder and take a one-minute count on each of the five scales of the counter. Record the results on the Gamma Scintillation Detector Operational Check Data Sheet.

3. Add the results and enter in the "Total Counts" column of the Operational Check Data Sheet.

   After enough daily data has been accumulated, prepare an Instrument Control Chart and transfer the data to the chart. Draw in the mean, and 1, 2, and 3 standard deviation lines. Continue the process as each daily count is made. If a daily total count falls outside the third standard deviation line, stop using the instrument until it has been repaired and re-calibrated.

## 6.3 Determination of Background Level

### 6.3.1 TSA MCA-465

Background Counting - Prior to use in the field a radiation-soil background check is performed for the detector. At the background location, ten 200 second readings are taken and recorded. A mean background count and the standard deviation from the mean are calculated and recorded.

**Note:** Background measurements should be performed in a known clean area adjacent to the location of interest in terrain similar to that of the target area.

#### 6.3.2 LMI 2221

Background Counting - Prior to use in the field a radiation-soil background check is performed for the detector. At the background location, five 60 second readings are taken and recorded. The mean background count is calculated and recorded.

### 6.4 Field Use

#### 6.4.1 TSA MCA-465

1. Be sure the instrument has been calibrated and contains charged batteries before going into the field. Check the batteries using the electrometer internal self-check.

2. At the measurement location in the field, set up the tripod and place the detector in the tripod. Place the electrometer as far away from the tripod as possible to prevent shielding of the soil sample to be measured.

3. Turn on the electrometer; after the self check, which verifies that the MCA recognizes an external probe is present, the instrument will be ready to record the field measurements. The instrument will be in the ROI mode after it is turned on. Begin the count by pressing the <START/STOP> key. The count time should be preset to 200 seconds, live time. If not, set to 200 seconds according to the procedure in Section 6.1.1 steps 11 and 12.

4. At the end of the measurement, the total number of counts in the regions of interest will be displayed on the Area Survey Sheet. See Attachment D.. Record the count values for the ROIs and the unique sample location. Repeat procedure at the next sample location, recording data at each stop.

5. If pertinent, store the field spectral measurement for a particular location in one of the 14 memory locations available in the electrometer. While in the ROI mode, hit STORE and select the Store Data option in the STORE menu. The measurement will be stored in the first available memory space. Record the memory area number in the logbook and associate it to a sampling location. When making a hard copy of data, the memory area number must be associated to the actual sampling location identifier.

6. The stored spectral data can be downloaded for further analysis from the MCA 465 using an RS-232 cable connected to a serial input port of a PC.

### 6.4.2 Ludlum 2221

1. Be sure the instrument has been calibrated and contains charged batteries before going into the field. Perform the daily response check and background check; verify that the instrument is "in control."

2. Determine the measurement location in the field; go to it and take the instrument with you.

3. Take the measurement at the height specified in the Work Plan.

4. If a grid point survey is being performed, the measurements should be integrated for 60 seconds, unless the approved work plan specifies a different integration period.

5. If a walkover survey is being performed between survey grid intersects, the instrument is used in ratemeter mode while listening to the audible signal for potential "hot spots."

6. At the end of the measurement, the total number of counts in the region of interest will be displayed. Record the count values for the ROI and the unique sample location on the Area Survey Sheet. Repeat this procedure at the next measurement location, recording data at each point.

## 7.0 REFERENCES

Ludlum Measurements, Inc. "Operating and Technical Manual - LMI 2221," Sweet Water, Texas, 1989.

TSA Systems Ltd. "Operating and Service Manual - MCA 465," TSA, 1820 Delaware Place, Longmont, CO, 80501, 1992, a.

TSA Systems Ltd. "Operating and Service Manual - External Probe Adaptor," TSA, 1820 Delaware Place, Longmont, CO, 80501, 1992, b.

## 8.0 RECORDS

### 8.1 TSA MCA-465

The data collected by the instrument can be recorded manually or stored in the memory locations of the electronics package. Information included with the data collection record includes name of personnel performing survey, date of sample reading, detector serial number, source check reference number, and date of last calibration. Stored information can be downloaded to a PC via the available software. Hardcopies of all pertinent information are transferred to the Records Processing Facility by the Operable Unit Project Leader.

### 8.2 Ludlum 2221

The data collected by the instrument will be recorded manually using the data sheets represented in Attachments A, B, C, and D. Information to be recorded includes name of personnel performing survey, date of sample reading, the raw data collected (gross cpm), location (grid coordinates), detector serial number, source check reference number, and data of last calibration. Hardcopies of all pertinent information are transferred to the Records Processing Facility by the Operable Unit Project Leader.

## 9.0 ATTACHMENTS

Attachment A - Gamma Scintillation Detector Operational Check Data Sheet
Attachment B - ESH-8 FIDLER Survey Sheet
Attachment C - Instrument Control Chart
Attachment D - Area Survey Sheet

**Los Alamos National Laboratory Environmental Restoration Program**
**GAMMA SCINTILLATION DETECTOR OPERATION CHECK DATA SHEET**

Ratemeter/Scaler Make & Model ______________ Serial No. ______ Calibration Expiration Date ______________

Detector Make & Model ______________ Serial No. ______ Calibration Expiration Date ______________

Source: Type ______________ Activity ______________ Identification No. ______________

Start Date ________ Technician Signature ______________ Reviewer Signature ______________

| Date | LMI-2221 One minute integrated response to check source (cpm) | | | | | MCA-465 ROI or LMI-2221 Total Counts | LMI-2221 One minute integrated background count (cpm) | | | | | MCA-465 ROI or LMI-2221 Mean Counts | Batt OK? | H.V. OK? | Audio OK? | Tech's Initia's |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | x1 scale | x10 scale | x100 scale | x1000 scale | Log scale | | Count No. 1 | Count No. 2 | Count No. 3 | Count No. 4 | Count No. 5 | | | | | |
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**Los Alamos National Laboratory Environmental Restoration Program**
**ESH-8 FIDLER SURVEY SHEET**

TA__________ OU __________ Subarea____________________ Date __________

Analyst(s)________________________________________

Instrument (Bicron) VIOLINIST/FIDLER Calibration Date __________ Probe No.__________

Check Source__________ Source ID No.__________ Activity__________

| Sample Location (Site ID#) | Pu $\mu Ci/m^2$ | Am $\mu Ci/m^2$ | Cs $\mu Ci/m^2$ | Region Of Interest Count/100 sec. | | | Comments |
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**Los Alamos National Laboratory Environmental Restoration Program**
**INSTRUMENT CONTROL CHART**

Ratemeter/Scaler Make & Model ______________________ Serial No. __________

Detector Make & Model ______________________ Serial No. __________

Source: Type __________ Activity __________ Identification No. __________

Start Date __________ Technician Signature __________ Reviewer Signature __________

| DATE | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ROI or Total Counts | | | | | | | | | | | | | | | | |
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**Los Alamos National Laboratory Environmental Restoration Program**
**AREA SURVEY SHEET**

Page ________ of ________

Job No. ____________________

Site: ________________ Date: __________ Technician ______________________________

Operable Unit: ____________________ RWP or Work Plan: ______________________________

Area Size ____________________ Grid Size: ______________________________

Purpose of Survey: ______________________________________________________________

__________________________________________________________________________

Instrument: ____________________ Serial Number: ______________________________

Detector: ______________ Serial Number: ______________ Background: ______________

Response Check: Should read: ______________________ Did read: ______________________

| Count Rate (CPM) | | | | | |
|---|---|---|---|---|---|
| Coordinates North | Coordinates East | | | | |
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Signature: ______________________ Reviewed by: ______________________________